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ABSTRACT

This paper highlights issues concerning the relationship between spatial reasoning and gender differences. It is noted that spatial reasoning can take on many different forms of expression, from geometric formations to abstract expressive creations. The definition of spatial reasoning for research purposes has been limited to a logical concept of reasoning. Thus, expressive spatial thought processes are excluded from existing interpretations of the subject. Summaries of some of the research on spatial reasoning and gender differences is presented. Four main areas of research are discussed: brain hemispheric specialization, sex hormones, the linking of sex and cultural practices, and research practices. The research tasks traditionally used in this field of study indicate that gender differences do appear with the performance of some tasks. In general the evidence indicates that females are more verbally acute than males, and sex differences are manifested in some tasks in regard to quantitative ability. (Contains 12 references.) (DB)

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Issues of Gender In Spatial Reasoning

Juried Paper Presented at the
National Art Education Association Conference
A Preliminary Overall View & Commentary
Chicago, 1993

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Issues of Gender in Spatial Reasoning

A Preliminary Overall View & Commentary

Presentation Agenda

I. Introduction 1
A personal introductory note 1

II. The Classic Definition of Spatial Reasoning For Testing 3
Spatial perception 3
Mental rotation 3
Spatial visualization 3
A Personal observation 3

III. Some Research Findings 5
Brain hemispheric specialization 5
Sex hormones 6
The linking of sex and cultural practices 7
Statistics and research practices 8
A Personal observation 9

IV. Some Conclusions and Suggestions 11
Defining a new form of expressive spatial thinking 11

V. References 12

Figures

Figure 1..... 3
Rod and Frame Test

Figure 2..... 3
The Water Level Test

Figure 3..... 4
Mental Rotation

Figure 4..... 4
Embedded Figures Test

Figure 5..... 6
Levy's Hand Posture Test

Figure 6.....13
La Pierre's Expanded Imagery

Figure 7.....14
The Water Level Test Restated Visually and Verbally

Tables

Table 1.....10
Research Patterns of Gender Differences

I. Introduction

The framework for the information found in this report is taken from Diane F. Halpern's book, *Sex Differences in Cognitive Abilities* (1992). This is an excellent resource book on the subject in regard to the summation of research methods and findings about differences between males and females. It covers the subjects of spatial reasoning and other cognitive differences in general. There is an enormous store of literature on this subject, and Halpern thoughtfully analyzes the subject without bias and reveals the immense complexity of the issues involved. There is a close tie between biology, psychology, and society in regard to how this topic has been framed for testing and research purposes. It has been a very "hot" issue because of the implications in regard to learning, intelligence, accessability to educational benefits, and the treatment of women in general.

This is an on-going research project and this paper is only the tip of the iceberg in regard to an overall view of the subject. Its purpose is to highlight the issues of spatial reasoning in regard to gender concerns and to open the door for more concentrated research in the field of art. The assumption being made is that the expressive spatial thought process does not fall under the present accepted interpretation or definition of the subject. Many of the observations are commentaries based on the cumulative patterns that were revealed in the review.

The study of visual-spatial ability is filled with contradictory research findings because of the multidimensionality (or various kinds) of such abilities. Halpern (1992, p. 70) states that "sex differences seem to depend on the type of test used." Halpern lists numerous studies that support these kinds of contradictory results. However, sex differences that favor males' scores are consistently found in two of the three factors (types of tests)---spatial perception and mental rotation tasks (see next section for these factors).

One major finding that has been reported in regard to performance on visual-spatial assessments is the variability of test scores. Some studies show men to be more variable than women, and others show women to be more variable than men. Halpern (1992) says the following in regard to this issue:

> One of the implications of group differences in variability is that predicting any individual's performance becomes more difficult.... Differences in variability also support the notion that there may be differences in the way men and women perform spatial tasks. Suppose, for example, that the women in the group sampled use different strategies. Perhaps some try to visualize an answer and others try to use verbal labels. These different approaches could result in increasing the variability in the women's scores. If men, on the other hand, tended to use a similar strategy, visualization for example, then their group might be expected to show less variability....One possible explanation of the inconsistent and contradictory findings with respect to sex differences in variability on visual-spatial tasks is that the differences among the results can be attributed to the nature of the tests. It is possible that women are more variable on certain visual-spatial tasks, and men are more variable on other types of visual-spatial tasks. (p. 71)

Quantitative and verbal abilities are not the topics of this report and will not be discussed in depth. However, as for spatial abilities, gender differences do show up in these areas in relation to some tasks. Some tasks show no sex differences and others do. In general the evidence indicates that females are more verbally acute than males, and sex differences are manifested in some tasks in regard to quantitative abilitity.

A Personal Introductory Note. It is my hope that men and women will stop fighting over this issue, but rather bask in the understanding that each individual brings to this world a unique expression of life, regardless of the human differences that are manifested. My position is to respect each others' strengths and idiosyncratic ways of expressing thought to help foster a world full of human beings that do not abuse, debase, or destroy. The issue of gender in regard to thinking must be approached on a positive level, one that is as free from research bias as possible. We need to stop using such terms as "better than" and value the best qualities that "manhood" and "womanhood" have to offer.

The quality of research and the validity of the conclusions reached are framed by the quality and integrity of the research from which they spring. This project is not a position paper, but rather a preliminary search for the salient issues to help foster better research and reporting practices. The result of not understanding theorectical constructs, cultural beliefs, and developmental issues that make-up various testing methods and instruments can contribute to a false impression that does not allow the female learner to reach her full cognitive expressiveness. Researchers must take the responsibility of thoroughly knowing the subject matter and how this body of knowledge applies to their findings---Where does their conclusion fit in the overall picture? Research findings should not advocate a sense of inferiority

created by group differences, but rather a sense of truth about how and why. I am not suggesting that as researchers we ignore differences between groups, but rather that we put these differences into perspective as to their nature, kind, and importance of meaning.

A study of history shows that humankind has attempted to test and measure aptitudes in all kinds of different ways. Gould (1981) in his book, *The Mismeasure of Man*, analyzes historically the various research forms and attempts at measuring intelligence. He illustrates the inconsistencies of theory development and the prejudiced attitudes that motivated them. This book reveals how intelligence was measured based on the size of the head and brain to the features of an individual's facial expressions. One could feel the obsurdity of many such attempts as described in this book. As the discipline of research became more sophisticated, reporting about the nature of intelligence became more humane and society became more aware of the false inequalities granted to various races and gender that were previously considered accurate.

This same kind of scenerio has been documented in regard to animals, as well. We once thought that apes did not have the ability to use language in a meaningful and thoughtful way. This issue is still riddled with controversy, but Linden's book (1981), *Apes, Men, & Language*, shows this not to be the case and that these animals are capable of thinking and feeling.

The point that I am trying to make by using the above examples is that we need to know more about the functions of different kinds of spatial reasonings and the mental processing involved in order to reach any conclusive findings about gender differences because the reported results may have far reaching educational implications for society's young. Our world is developing new ideas at a very fast pace. This kind of progressive knowledge is as fluid and common as the advancing development of the computer and other technological inventions.

II. The Classic Definition of Spatial Reasoning For Testing

It is agreed that spatial reasoning is not unidimensional in nature (meaning a single concept), but mutlidimensional (meaning that different kinds of spatial abilities exist). Linn and Petersen (cited in Halpern, 1992, pp. 68-71), analyzed visual-spatial abilities tests and found three common factors as being the basis used for assessment purposes. These three factors are as follows:

1. Spatial perception. This kind of testing requires the subject to locate the horizontal or vertical while ignoring distracting information that may surround it. Examples of this kind of testing are the rod and frame task and Piaget's Water Level Task (see Figures 1 and 2).

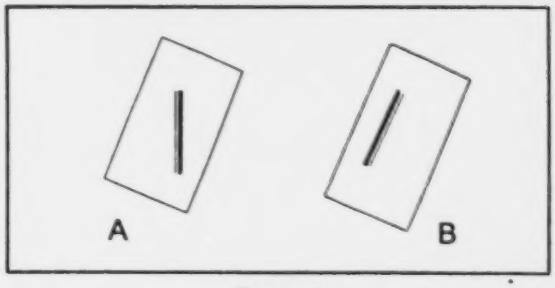

Figure 1
Rod and Frame Test.
Align a rod within the frame so that the rod is verical.
The rod is not correctly positioned in B.

---

2. Mental rotation. This is defined as the ability to imagine how objects will appear when they are rotated (see Figure 3).

3. Spatial visualization. This is defined as multistep processing of information. Examples of this kind of testing are the embedded figures test, paper folding, hidden figures, and spatial relations tests (see Figure 4).

The above three tests are the basis of the conceptual underpinnings (or constructs) that comprise the testing of spatial reasoning in general. These theoretical concepts define the figures, images, or forms as geometric and representational (visually symbolic) in nature. According to Linn and Petersen (cited in Halpern, 1992, p. 67), "Spatial ability generally refers to skill in representing, transforming, generating, and recalling symbolic, nonlinguistic information." It is assumed that the above representational or pictorial concepts are representative of the activities that take place in the mind in regard to visual-spatial reasoning. There is no distinction made in these kinds of tests between the non-linguistic manipulation of symbolic mental imagery (as seen in Figures 1-4) and that of abstract mental imagery (as described in Section IV of this paper). The classical or traditional kind of testing is very linear in nature and many individuals can talk themselves through the process to reach an answer, reducing it to a verbal skill.

Figure 2
The Water Level Test
The concept of a real world context. This glass is half filled with water. Draw a line across the glass to indicate the top of the water line. This drawing is cited in Halpern (1992) and comes from S.C. Kalichman (1989). The effects of stimulus context on paper-and-pencil spatial task performance. *Journal of General Psychology*, 116, 133-139.

For a good review of how spatial reasoning came to be defined by Piaget and others, refer to Dixon's (1983) chapter on "What is Spatial Ability?."

A Personal Observation. Belenky, Clinchy, Goldberger, and Tarule (1986) in *Women's Ways of Knowing*, interviewed 135 women and described their views of reality in regard to truth, knowledge, and authority. The assumption made by the investigators was that men drew on their own perspectives and visions and constructed the prevailing theories to set values that have become the guiding principles for men and women alike (p.5).

These reseachers also found that the woman's point of view was "her voice" and that she used this metaphor to depict intellectual and ethical development, meaning speaking and listening, dialogue and interaction. Engagement, connectedness, and conversation were repeated themes that this study reported. Communication was also the issue when

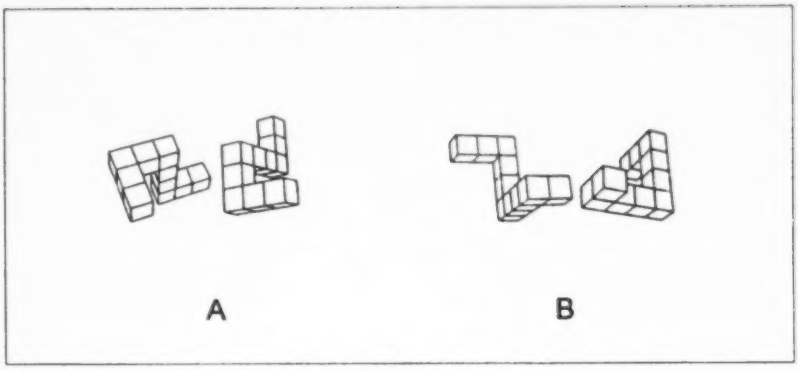

Figure 3
Are these pairs of figures the same except for their orientation?

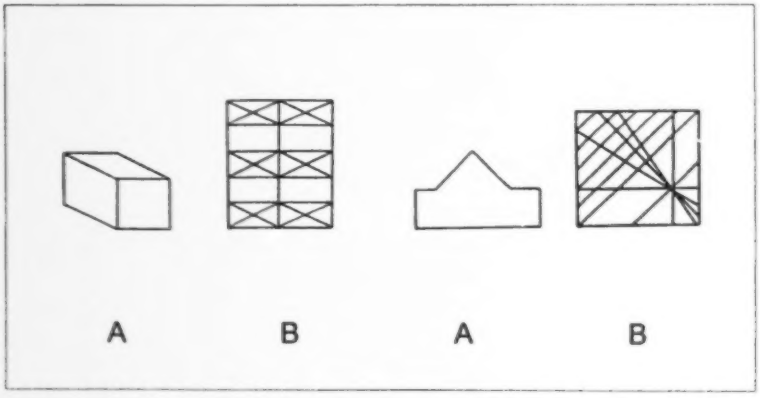

Figure 4
Is Figure A part of Figure B?

Bowlds (1985) and Connor and Serbin (1977) (cited in Belenky et al., 1986, p.18) found that three and four-year-old girls were much more likely than boys to choose the telephone as a preferred toy.

It appears from these studies that words, communication, connectedness, and interaction are important factors for women for whatever reasons. If we look at these findings in relationship to the rod and frame test, for example, the instructions shown in Figure 1 state to "align the rod 'within' the frame so that the rod is vertical." The rod in example B is positioned "within" the frame, using the frame as the reference. But, the correct response would be A where the rod is verticle overall. Conclusions reached by the researcher might be that the first response is given by a *field dependent* person whose judgement is influenced by surrounding information. On the basis of these kinds of tests, Witkin (cited in Halpern, 1992, p.75) described women's cognitive style as "global," "conforming," and "child-like." I am suggesting here that the verbal instructions might be more important to women than originally thought.

Let us look at the instructions in Figure 2 in this same light. The instrucions for the Water Level Test asks the participant to "draw a line 'across' the glass to indicate the 'top' of the water line." Halpern (1992) indicates that numerous studies have found sex differences on this task. Women tend to perform less well. It does not seem logical that women do not understand how water flows out of a glass when drinking. Perhaps the directions are not well stated, creating a limitation of the study that is sex-biased. Suppose the wording were changed to---"indicate the water level by drawing a line."

This may seem like a minor issue, but if girls are socialized differently from boys, as documented in almost every country in the world, a mole hill might actually be a mountain in regard to understanding. So, performance on a test cannot be accurately assessed if the participant is not sure what is being requested.

III. Some Research Findings

Brain Hemispheric Specialization. Broca's school of thought in the 1800s (cited in Gould, 1981) proclaimed that women were inferior to men and akin to Black men and apes because of the smaller size of the brain. Their intelligence was not well developed and represented inferior forms of the human evolutionary experience. How obsured this all seems now. But, the consequences for woman and races other than White was considerable. It affected their education and society's treatment of these "inferior" beings. It was assumed that the woman's thinking process was absent of all logic, and this kind of reasoning kept women, as well as African-Americans from voting.

Researchers are still questioning whether the brain is the same for the male as for the female. Are the brain functions the same for each sex? According to Gersh and Gersh (1981) as cited in Halpern (1992, p. 139), "Microscopic examinations of the structure of the nerve cells and nerve tissues that comprise the brain would show that the cells are morphologically identical except for visible X chromosomes (known as Barr bodies) in many of the nerve cells in women's brains and Y chromosomes in the men's nerve cells." This is a clear indication that there are some sex-related brain differences, and menstruation is an example of the manifestation of this difference. But, does this mean that women are not equal to or radically different in their thinking process from men? According to Halpern she states "There is no reason to believe that the portions of the brain that regulate menstruation in females and sexual behavior in males and females are also involved in the higher cognitive functions." (p. 140)

Looking at modern thought, it has been assumed that because sex-related differences do occur in testing, such as verbal abilities and visual-spatial skills, this would suggest that the sexes differ in the way their hemispheres specialize these abilities because each hemispheric specialization differs with respect to these abilities (Halpern, 1992, p. 141). There is a large body of knowledge that confirms the lateralization of the brain for different cognitive functions (Mayer, 1983; Halpern, 1992). According to Halpern (1992, p. 141), "Hemisphere dominance does not mean an either/or division of tasks. It means instead that one half of the brain is more or less specialized or proficient in its ability to process certain types of stimuli." It is accepted thought that the left hemisphere is more verbally specialized and the right hemisphere is more spatially specialized.

A large amount of research literature in regard to hemispheric dominance and handedness (the differences between right and left handers) exists. The findings in this area of research show some consistent cognitive differences. According to Coren (1990) as cited in Halpern (1992, p. 143) a greater proportion of males are left-handed than females, and, thus, "because left-handedness is statistically associated with being male and right-handedness with being female, the similarity in cognitive patterns is not surprising." There appear to be many parallels between findings of cognitive sex differences and handedness differences. For example, Halpern (1992) states:

> Reading disabilities, stuttering, and some categories of mental retardation are more prevalent in males than in females and in left-handers than in right-handers. Similarly, precocious mathematical giftedness is more likely found in males than in females and in left-handers than in right-handers (Benbow, 1988). Precocious verbal ability (as measured on the SAT-V) is also associated with being male and left-handed (O'Boyle & Benbow, 1990). Although this result seems to run counter to the "typical" sex difference in verbal skills, recall...that males now outscore females on the SAT-V. I speculated earlier that this seemingly anomolous result may be due to the large number of analogies on the SAT-V. Analogies seem to be the one "verbal" skill at which males tend to score higher than females. (p.143)

The question that arises is how can handedness be determined effectively and does this indicate the true hemispheric dominance of the individual and if it does, what does this really mean? There seems to be a cognitive pattern for males and left-handedness and for females and right-handedness. Eventhough handedness is an indirect measure of brain activity, various methods have been devised to determine brain hemispheric dominance. For example, one such method by Levy (1974) as cited in Halpern (1992, p. 144) looks at writing hand posture as an indication of language specialization (see Figure 5). According to Levy if the hand is "hooked" in the writing process, this indicates same side brain lateralization and an "upright" hand posture indicates opposite side lateralization for verbal abilities.

Another theorectical method of determining which side of the brain is most used relates to the direction in which the eyes gaze when a question is asked and the individual refects on the answer. According to Kinsbourne (1972) as cited in Mayer

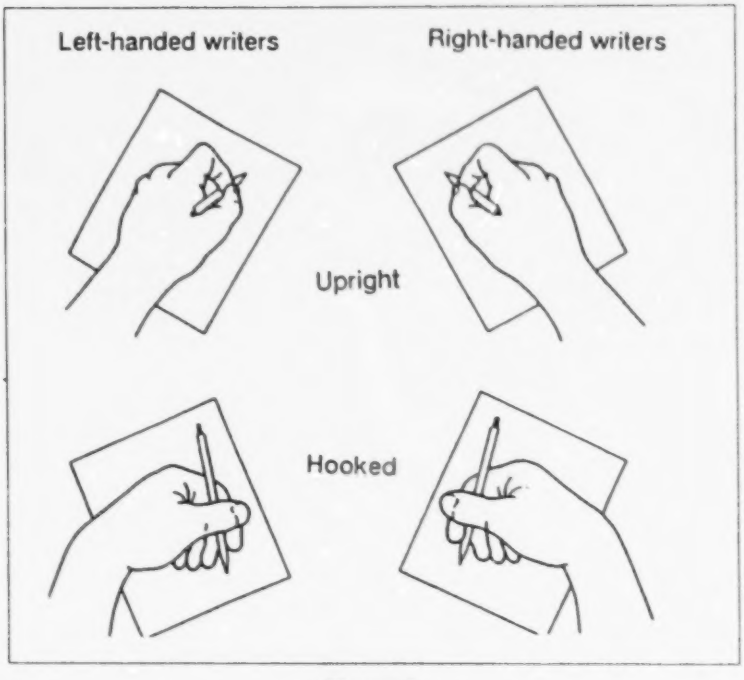

Figure 5
The use of writing hand posture to determine which brain hemisphere is lateralized for verbal abilities. This figure is taken from Levy (1974) as cited in Halpern (1992, p. 144).

(1983, p. 23), as an individual thinks about a question, s/he might gaze to one side. It is hypothesized that the direction of the gaze is correlated with the side of the brain being most used. He found that certain kinds of questions elicited gazes to the right and others to the left, thus determining which side of the brain was in operation.

The fascination with brain lateralization has produced a proliferation of research studies in regard to bilateral organization (meaning that the two hemispheres show less of a difference in responding to stimuli) and lateral or one-sided brain organization. According to Halpern (1992, p. 146), "The hypothesis that women's brains are more bilaterally organized (which implies that males' brains are more laterally or one-sided organized) is hotly contested in the research literature." However, there is research in the areas of hearing and vision to indicate that different patterns of lateralization in females and males may be a possibility. Again, the type of testing may be a factor. However, the data indicates that women have lower occurrences of language disorders and are less impaired by localized brain injury. Women have fewer reading disabilities (which includes dyslexia), fewer speech disorders (such as aphasia, dysphasia, and stuttering), and lower autism rates. This information comes from research by McGlone (1980) and Witelson (1976) as cited in Halpern (1992, p. 151).

Levy (1976) as cited in Haplern (1992, p. 149) suggests that "females are more likely to involve both hemispheres when solving spatial tasks than males." Levy tested neural activity by the use of electroencephalograms (EEG's) and found "The patterns of electrical activity suggest that boys tend to use their right hemispheres when performing spatial tasks while girls use their left hemispheres for both spatial tasks and verbal tasks." Is this a further indication that perhaps the organization of the brain is more bilateral in women? The research does suggest that such a pattern may indeed exist.

Sex Hormones. Females and males have various quanities of estrogen, progesterone, and testosterone in their systems throughout their lives. These "female" and "male" hormones are present at various stages of development. For example, the androgens (or male hormones) start the development of the male infant about seven weeks after conception. According to Halpern (1992, p. 111), "It is important to note that it is the absence of male hormones, not the presence of female hormones, that directs the growth of female organs because in the absence of hormones, or usable hormones, the sexual differentiation of the fetus will be female." Halpern goes on to say "There is good evidence that the presence or absence of particular sex hormones during critical stages of prenatal development also plays a role in the sexual differentiation of the developing brain." (p. 112)

The research information as to the kinds of differences that "female" and "male" hormones play in the developing neural system is somewhat limited to research that has been done on rats and nonhuman mammals. Part of the problem here is that these animals are not exactly like humans in every respect, so the data need to be viewed with this in mind. Probably the main difference between animals and

humans is the fact that hormones play a greater role in directing behavior in animals.

The area of research in regard to sex hormones is very complex because it is difficult to separate the effects of hormones from other variables in the research process. In using animals for research, researchers have attempted to manipulate the hormone factor by either castrating the developing male or by removing the ovaries of the developing female. One finding by Kimura (cited in Halpern, 1992, p. 113) indicated that testosterone can create asymmetrical (or lateral) effects on the developing brains of prenatal female and male rats. What is clear about the research using rodents is that prenatal hormones do influence sexual behavior, aggression, maze learning (equated with spatial activity), and in general "male hormones" produce typical male behavior. The removal of male hormones produces typical female behavior in the results.

There is much more research in this area, but the main focus of this section is to confirm that prenatal hormones play an important role in the developing characteristics of the "female type" and "male type" behavior patterns in regard to brain development. Much more research is needed to understand how, why, and when prenatal hormones affect cognitive abilities, because this is not a simple subject and the findings are contradictory in this area as well. Human beings have many factors that need to be considered to determine what is responsible for sex differentiated patterns of cognitive abilities. Is it due to hormones, maturation rate, or on-set of puberty?

It is hypothesized, however, that levels of androgens do influence the full development of spatial ability for males and females. But, it has not been scientifically demonstrated that high levels of androgen hormones (mediated by testosterone) correlate with good spatial ability. What complicates the issue is that androgens are chemically converted to other hormones for use in the brain. One other hormone of this nature is estradiol, a hormone secreted by the female ovaries. According to Nyborg's theory (cited in Halpern, 1992, p. 124), it is this hormone that is responsible for the optimal expression of spatial abilties. Confusing? Well, consider yet another hypothesis related to this theory. Males who are more "feminine" (higher levels of estradiol) and females who are more "masculine" (lower levels of estradiol) will have better spatial skills. There is some research to indicate that superior spatial ability is associated with more male hormones for females and less male hormones for males (Petersen, 1976; Maccoby, 1966) as cited in Halpern's analysis (1992, p. 123). It is also important to remember that social and environmental aspects play an important role in stages of development and cognitive expression, as well.

The Linking of Sex and Cultural Practices.

There is no doubt that women have different life experiences from men. This is true of every country in the world, and in some countries specific actions are reserved only for women and some only for men. The assumption that is made in regard to sex differentiated social practices is that they reflect the natural biological propensities of each sex. Environmental and social factors play a great role in the cognitive development of both girls and boys. The question is just how much of a role do these factors play in terms of intellectual performance?

Our society still uses the male as the norm, and much of this is so ingrained that we do not know it exists. Sex differences in socialization practices include the toys we play with, the words we use, the clothes we wear, the forms we fill out, the surnames we use, and so forth. For example, according to Halpern (1992, p. 176) there is a "considerable body of evidence that people tend to think of males, and not males and females, when they encounter terms like the *generic he* " in language. One aspect I have experienced in regard to language and male bias is that people in my field are referred to as *Dr.*, especially in academic settings or activities. Even when people know I have a doctorate, I am referred to as *Ms.* We expect men to be researchers and qualified, but our expectations of women seem lower, and as a society we have stereotypes about different practices.

One common sex role stereotype is that women are more "conforming" and easily influenced. This reminds me of the rod and frame test results for women. They are found to be more "field-dependent" or influenced by the surroundings. I pointed out in my discussion that this may be a finding due to the language used in the testing method. But nevertheless, these kinds of results, even though language limitations, research practices, or constructs may be questionable, add to the overall belief that has created this stereotype about women. Becker (1986) as cited in Halpern (1992, p. 180), reviewed the literature on social pressure and concluded that "There was no statistically significant difference between the sexes in the tendency to conform to social pressures."

The fact remains that life's experiences sometimes forces men and women alike to conform to patterns of behavior that are prescribed by gender. These kinds of behaviors may not be related to

cognitive development but yet influence the expression and expectations of achievement in relationship to educational practices and thought. Therefore, sex role stereotypes may influence the creation of sex differences. I know from my own experience when I received my masters degree in 1970, I was told at numerous job interviews that they would not hire me because my husband would most likely not follow me to the job (an assumption they made based on traditional practice at that time). He also graduated at the same time and did take a job offer. But the fact remained that this kind of stereotyping created a situation that led to sex differences in the sense that I did not establish myself in the university or business worlds until sometime later. Yet, I graduated with honors and worked full time as the only support during graduate school days.

Let me relate one more personal observation as an example of socially created stereotyping. In the state of Colorado, as in most other states and the federal government, couples sign their income tax returns as *taxpayer* and *taxpayer's spouse*. You say that a working woman may also sign as taxpayer if she is married. This is possible, but it is not a social habit. Not only is the woman expected traditionally to sign on the second line, but all joint tax returns are filed under the husband's social security number as the taxpayer, since he is generally listed as the taxpayer. Hence, only his social security number heads each tax return page, and in order to retrieve tax information the huband's social security number must be given. Twenty years ago the tax forms used to read: *taxpayer's signature* and *taxpayer's wife's signature*. I know because I petitioned the IRS to change the wording in Colorado. This is a very subtle indication of how society sees the woman's role and the value of her existence. Granted these are personal experiences, but they are meant to illustrate the fact that this kind of stereotyping does still occur and can create or foster sex differences because of manufactured gaps.

If these kinds of activities are still occuring, perhaps we as researchers should indeed question how tests and assessment practices are conducted and reported. To ignore these influences as variables is not responsible reporting. According to Halpern (1992, p. 187-188), "Learning theorists explain the acquisition of sex roles by positing that children are rewarded when they evince appropriate sex role behaviors and attitudes and punished for behaviors and attitudes that do not conform to the sex appropriate roles----Thus, according to Learning Theory, through sex differentiated rewards and punishments children learn that mathematical and spatial activities are more appropriate for boys and that reading and other verbal activities are more appropriate for girls." And, there is increasing evidence that IQ scores are consistently declining for girls, especially in the identified "gifted" area (Noble, cited in Halpern, 1992, p. 201).

Statistics and Research Practices. A great many studies are done in graduate schools where students are learning how to conduct such research. If a professor advises numerous students, plus teaches full time and continues to do research on a personal level in order to keep his/her job, supervision of graduate research projects may be at a minimum. To check students' statistical figures and results takes a great deal of time. Personally, I think that the demands made on many professors are heavy and do not allow for total review of research methodology, search of the literature, and conclusions that students make in order to graduate. Yet, many of these research projects are published in major journals because the professor may lend his/her name for that purpose. The projects are also published in *Dissertation Abstracts* for others to review and quote. Many institutions expect the research findings of empirical studies to have significant statistical differences. If significant differences do not occur, the student may have to do another project. What if the research did not render significant differences between male and female? That is the question. Should it be published? Should the student be allowed to finish? According to Halpern (1992), this is indeed a major issue and searches of the literature will in all probability deal with statistically significant differences as published material because it is a standard practice. She states "If only studies finding sex differences appear in the published literature, then it is easy to see how incorrect conclusions are reached." (p.44)

Another issue that needs to be looked at in regard to research results is the raw data. What is the shape of the distribution of scores and what is the variance factor? What is the frequency count in regard to scores? Again, Halpern (1992) discusses this issue in depth. The mean score can be deceptive in reporting research results because there may be a spread of scores creating a large variance. This variance could be an indication that the constructs are not really what is being tested and the assumptions are not valid. On the other hand, if one instrument is being used to validate another instrument (concurrent validity) and the constructs are of a different nature, this may show up in the degree of variance. A large

variance can also be an indicator that the groups being compared are very different in nature.

This brings up another issue in research reporting, Effect Size. What is the true difference between the groups being studied? Is the difference large or small? Is the difference theoretically or practically meaningful or important? Let me quote an example from research as cited in Halpern (1992). Halpern states the following:

> Eagly (1987) has compared effect size indicators for several differences in social behavior. Let's consider differences in agressive behavior. She reported that sex differences account for only 2 % of the variance in aggressive behavior. (This is the w2.) [1] This certainly sounds like a very small effect. The corresponding d = .29, or slightly less than one third of a standard deviation.[2] This is conceptually a "small" effect. However, when we examine the BESD, the effect size seems much larger---43% of the females and 57% of the males scored above average on the measures of aggression. These three indicators of effect size all apply to the same set of data. The value of w2 seems quite small, while the BESD seems quite large. (p. 53) [3]

According to Feingold (1992, p. 434) when summarizing multiple comparisons yielding various variance ratios (VR's) to determine an overall difference, "VR's are not normally distributed and must be transformed before they can be used in correlational or mutlvariate analyses." As one can see, you are not going to get away from the average when using stats for comparisons. The statistical aspect of research is extensive and always changing. It requires knowledge and often professional statistical advise in order to report properly. In my opinion professional statistical review should be built-in to every research project.

Because the issue of gender difference is so "hot," researchers should employ multiple measures to test theorectical constructs. The definition of terms is a very important issue, because like spatial reasoning, each researcher may have his/her own specific definition of terms. The results of any study reflects how the terms are used to verify claims. If sex differences are consistently found on all measures, regardless of the definition of terms, then a more consistent pattern of findings can be reported that may have meaning. This involves the analyzing of multiple indicators.

A Personal Observation. I commend Halpern (1992) for her astute analysis of the issues in regard to sex differences and the thinking process. She struggled, as should any good researcher, to report the findings and to be free of any bias that would lead researchers to close their eyes to consistent patterns found in the literature. All of the data must be looked at with an overall understanding of the research process---methodology, statistics, and definition of terms based on theorectical constructs. There is much that is not known about the human thinking process and how it is applied. There is also much that is known because of consistent patterns that surface in the literature (see Table 1, page 10, for summary). The concept of visual-spatial reasoning is based on how one defines what and how it is expressed or applied (operationalized). It is apparent that this cognitive process is expressed differently by males and females. As to what this means, researchers are still making determinations. One thing is for sure---men and women express strengths and weaknesses as a group and as individuals. Contradictory information and findings can be a result of factors such a measurement problems, samples and populations, bias, definition of terms, use of abnormal populations for inference, and use of nonhuman research samples to name a few.

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1. w^2 = a measure of the proportion of total variance in a data set---based on an average (median) use.
2. d = a measure of the magnitude of the difference between two groups

$$d = \frac{\text{M (males) - M (females}}{\text{SD (Standard Deviation}}$$

3. **BESD** = Binomial Effect Size Display or the percentage of each sex that is above the average response in the combined group of males and females.

Female	Male
• X Chromosomes in brain cells	• Y Chromosomes in brain cells
• more verbal on some tests	• more spatial on some tests
• right-handedness association	• greater proportion of left-handedness
• more bilateral organization of brain functions---meaning that language functions are represented in both hemispheres (one major theory supported by a consistent pattern of research in several areas).	• more lateral organization of brain functions---meaning language in one hemisphere and spatial in the other (one major theory supported by a consistent pattern of research in several areas).
• exhibit secondary sex characteristics earlier and develop reproductive capabilities earlier.	• more reading disabilities (which includes dyslexia)
• posterior portion of the corpus callosum is larger (a thick band of neural fibers connecting the hemispheres)---supports the bilateral organization theory.	• more speech disorders (such as aphasia, dysphasia, and stuttering)
• better on tasks of manual dexterity (praxia).	• more autism
	• slower on-set of puberty
	• posterior portion of the corpus callosum is smaller (a thick band of neural fibers connecting the hemispheres)---supports the lateral theory.
	• more biologically vulnerable from conception to death---105 males born for every 100 females and they die at a younger age.

Table 1
Summary of some research **patterns** in regard to gender differences. Not all of these items are discussed in detail in the text of this report (see Halpern, 1992, for more details and sources).

IV. Some Conclusions and Suggestions

Defining a New Form of Expressive Spatial Thinking. It seems that the concept of spatial reasoning can take on many different forms of expression, from geometric formations to abstract expressive creations. The process of reasoning is to act-out thought in a logical way for the purpose of solving a problem or creating an idea. The problem with the concept of thinking logically is that it is interpreted as being linear, sequential, or progressive in nature (La Pierre, 1992). It is not expressive or interpretive, and I believe that the definition of visual-spatial for research purposes has thus far been limited to this logical concept of reasoning. The manipulation of objects in space is more formalized and rigid.

The theorectical constructs of most measurement procedures use geometric forms that are easy to represent, assess, and understand by the general practitioner or researcher. However, I believe that another spatial thought process exists that can be measured (La Pierre, 1988, 1992). It is based on the concept of solving a problem. Visual artists use this method to create and express. My research of professional adult artists has shown that there is a conscious level of awareness in regard to intrinsic versus extrinsic matters. The artists are aware of how outside influences affect them and their thinking processes, but they manage to mantain a personalized sense of independence. They have the ability to imagine changes and consequences in thought as an innovative, expansive reasoning process based on jumping and leaping (non-conforming). Mental placement of shapes and forms is not necessarily based on such factors as sequential, geometric, realistic or symbolic formations. It is perhaps abstract in nature, undefinable is words, and unrecognizable in shapes. There is a difference between the recognition of shapes and objects and the ability to understand space and to use it as a form of reasoning. According to Dixon (1983, p. 27), "Spatial understanding depends on grasping the consistency in relationships between things when these relationships occur in the context of fluid, changing patterns. The fluidity presents infinite possibilities like a face seen from different angles."

Unlike Finke's (1990) concept of using "preinventive forms" in order to discover and invent, the artists appear to re-invent and mentally adjust existing forms to explore visual and spatial possibilities. The mental space or parts are not just rearranged in a visual format, but rather the space is pulled and stretched and actually changed in size and shape (contour, scope, dimension)---like a mental exploration into the extremes (see Figure 6, page 13). More research needs to be done in regard to the issue of gender differences. But, I think that this definition of spatial reasoning is more expansive and flexible and may allow for females to express spatial intelligence in a way that is not compared to males.

The present pencil and paper tests of assessment are barren line illustrations that do not exhibit true context or convey meaning. Expressive subject matter and content might allow individuals to understand what is being asked of them. For example, going back to the Water Level Test, what if the visual aspect of the test were more appealing and the instructions asked for a solid water level (meaning a shaded or filled-in response) instead of a single line to indicate the water level (see Figure 7, page 14)? Might contextural changes of this nature make a difference in how females respond?

The arts are idiosyncratic in nature and practice, and the individual is encouraged and taught to use space on a visual level as a medium of personal fulfillment. Clark (1993) uses a criteria scale to test high ability art students on drawing tasks. He suggests that this instrument not be the sole measurement tool used to assess ability in the visual arts. Perhaps this is the key to testing for any cognitive ability. We do know from Dennis' research (1991) that there is a link between the structure of children's art (representative of the spatial domain) at various ages and the general structure of their developing cognitive system. Different individuals perform in different ways based on such factors as natural ability levels (talent), experiences and exposure, drive and desire, sensitivity to visual or aesthetic perceptions, intelligence levels, memory structures, or practice and concentrated instruction (mastery level). Any one of these factors could make a student (female or male) better than average.

V. References

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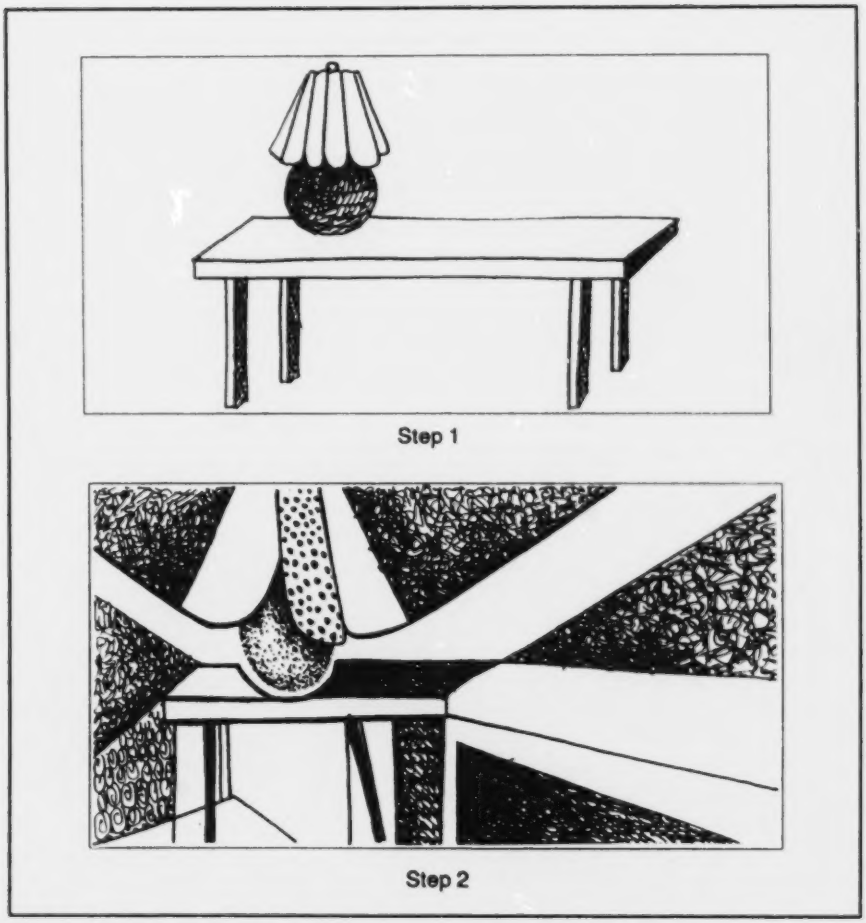

Figure 6
Step 1 = Static Realistic Imagery.
Step 2 = Expanded Spatial Imagery---Expressive, Interpretive, Abstract in Nature.

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Figure 7

The Water Level Test Restated Visually and Verbally.

Test Instructions: When watering flowers what is the water level when the pail is half full of water? Shade in (fill in) the water level using a pencil.